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Comprehensive Long-Term Environmental Action Navy (CLEAN)
Contract No N62742 94 D-0048
Contract Task Order No 0030

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Camp Covington

Draft Work Plan

Abbreviated Remedial Investigation

New Apra Heights Disposal Area COMNAVMARIANAS, Guam

Prepared for

Department of the Navy
Commander Pacific Division
Naval Facilities Engineering Command
Pearl Harbor Hawaii 96860 7300

Prepared by

Earth Tech, Inc
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Honolulu, Hawaii 96813

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ACRONYMS AND ABBREVIATIONS

ARARS	applicable or relevant and appropriate regulations
BCP	BRAC Cleanup Plan
BCQ	Bachelor Civilian Quarters
bgs	below ground surface
BRAC	Base Realignment and Closure
CEM	conceptual evaluation model
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CLEAN	Comprehensive Long Term Environmental Action Navy
COMNAVMARIANAS	Commander U S Naval Forces Marianas
CPEC	contaminant of potential ecological concern
CTO	contract task order
DoD	Department of Defense
DQO	data quality objectives
Earth Tech	Earth Tech Inc
EBS	environmental baseline survey
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
ERA	ecological risk assessment
ERAGS	Ecological Risk Assessment Guidance for Superfund
FSP	Field Sampling Plan
GOVGUAM	Government of Guam
GP	government property
HRA	human health risk assessment
IDW	investigation derived waste
IEUBK	Integrated Exposure Uptake Biokinetic Model
IR	Installation Restoration
mg/kg	milligram per kilogram
NAVACTS	Naval Activities
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFRAP	No Further Response Action Planned
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no-observed adverse effect level
Ogden	Ogden Environmental and Energy Services Co Inc
PACNAVFACENGCOM	Pacific Division Naval Facilities Engineering Command
PAH	polynuclear aromatic hydrocarbon
PBEC	Pacific Basin Environmental Consultants Inc
PCB	polychlorinated biphenyl
POI	point of interest
PRE	preliminary risk assessment
PRG	preliminary remediation goals

PWC	Public Works Center
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RDBMS	relational database management system
RI	Remedial Investigation
RME	reasonable maximum exposure
RPM/NTR	Remedial Project Manager/Navy Technical Representative
SARA	Superfund Amendments and Reauthorization Act
SHS	Southern High School
SI	Site Investigation
SMDP	scientific/management decision point
SOP	standard operating procedure
SVOC	semi volatile organic compounds
TBC	to be considered
TAL	target analyte list
TPH	total petroleum hydrocarbon
TQ	toxicity quotients
TRVs	toxicity reference values
µg/kg	micrograms per kilogram
USDA	United States Department of Agriculture
USFWS	U S Fish and Wildlife Service
VOC	volatile organic compound
WP	work plan

1 INTRODUCTION

This document is the Work Plan (WP) for the abbreviated remedial investigation (RI) at the New Apra Heights Disposal Area on Guam (see Figure 1 1) The New Apra Heights Disposal Area will be referred to as the Site The WP was prepared for the Pacific Division Naval Facilities Engineering Command (PACNAVFACENGCOM) under the Comprehensive Long Term Environmental Action Navy (CLEAN II) Program contract no N62742 94 D 0048 contract task order (CTO) No 0030

The sampling procedures protocols and the quality assurance project plan for the RI are contained in the *Sampling and Analysis Plan Abbreviated Remedial Investigation New Apra Heights Disposal Area COMNAVMARIANAS Guam* (Earth Tech 1998b)

- Safe work practices and emergency response procedures are described in the Health and Safety Plan (Earth Tech 1998b Appendix)

The standard operating procedures (SOPs) applicable to the RI appear in *Project Procedures Manual U S Navy PACNAVFACENGCOM Installation Restoration Program (IRP)* (DON 1996)

1 1 PROJECT HISTORY

Environmental Impact Assessment (PBEC 1993) An Environmental Impact Assessment (EIA) examined the probable impacts on upland and wetland habitat and fauna of building and operating the Southern High School (SHS) located east of the Site In the higher elevations archaeologists found small amounts of modern junk including bottles car parts and other assorted metallic debris —some probably dating from the World War II era Five concrete pads were found on the upper second terrace apparently the foundations of Quonset huts or World War II housing Investigators concluded that upland and wetland habitats would likely be lost or modified and fauna displaced as a result of noise dust, and erosion (from clearing and grading) during construction of the school Plans for erosion control environmental protection and wetland mitigation were proposed to lessen possible impacts on the environment

Southern High School Site Investigation (Ogden 1995) The discovery of stained soil and buried scrap metal during construction of SHS led to a Site Investigation (SI) to assess the nature and extent of contamination Soil gas surface soil and subsurface soil samples were collected throughout the SHS site and from off site locations where excavated soil had been deposited Elevated levels of volatile organic compounds (VOCs) semi volatile organic compounds (SVOCs) total petroleum hydrocarbons (TPH) polynuclear aromatic hydrocarbons (PAHs) metals and explosive residues were detected in a pile of scrap metal and in a 26 foot high mound of soil created during construction Buried subsurface metal debris was observed extending onto the New Apra Heights parcel A geophysical survey of the SHS site found buried debris extending across the access road to the Building 4175 parcel

A human health risk assessment determined that the soil within the scrap pile and soil mound constituted a potential threat to public health other areas did not warrant concern The SI report recommended removing the contaminated soil mound and pile of scrap metal The SI report also recommended a thorough review of historical records to ensure no other contaminated areas exist onsite

Environmental Baselıne Survey (Ogden 1996b) An Environmental Baselıne Survey (EBS) of U S Navy property on Guam documented environmental conditions at the New Apra Heights and the Buıldıng 4175 parcels Surveyors classified the environmental condition of the Building 4175 parcel and a 100-foot wide strip of the New Apra Heights parcel as Category 7 i e unevaluated or requiring additional evaluation because of the potential for migration of contaminants from the SHS complex The EBS was conducted as a result of the findings in the Base Realignment and Closure (BRAC) Cleanup Plan (BCP) The BCP stated that the New Apra Heights referred to as Point of Interest (POI) 07 posed a potential threat to the SHS and adjacent property (Ogden 1996a)

Geophysical Survey (Earth Tech 1997) A non intrusive geophysical survey of the Site confirmed the presence of subsurface debris in an oval shaped area at least 480 000 square feet (11 acres) in size The results of the geophysical survey are shown in Figure 1 2 The report recommended a biological reconnaissance survey to identify ecological receptors at risk from future intrusive activities and Site contaminants trenching to visually identify subsurface debris and soil sampling to assess the nature and extent of contamination

Biological Reconnaissance and Wetland Delineation (Earth Tech 1998a) A biological reconnaissance of the New Apra Heights Disposal Site identified habitat types on and adjacent to the Site surveyed migration pathways for hazardous constituents and identified possible human and ecological receptors

Major habitats include modified secondary forest (Tangantangan scrub woodland) grassland/ savanna, and wetlands Five wetland areas found on the Site (see Figure 1 3) were designated wetlands A through E The wetland boundaries extend into both the modified secondary forest habitat and the savanna habitat The boundaries were delineated by wetland biologists and the jurisdictional boundaries were surveyed by a licensed surveyor The surveyed boundaries were inspected and approved by the Division of Aquatic Water Resources Plant and animal communities including endangered species are discussed further in Section 2 1

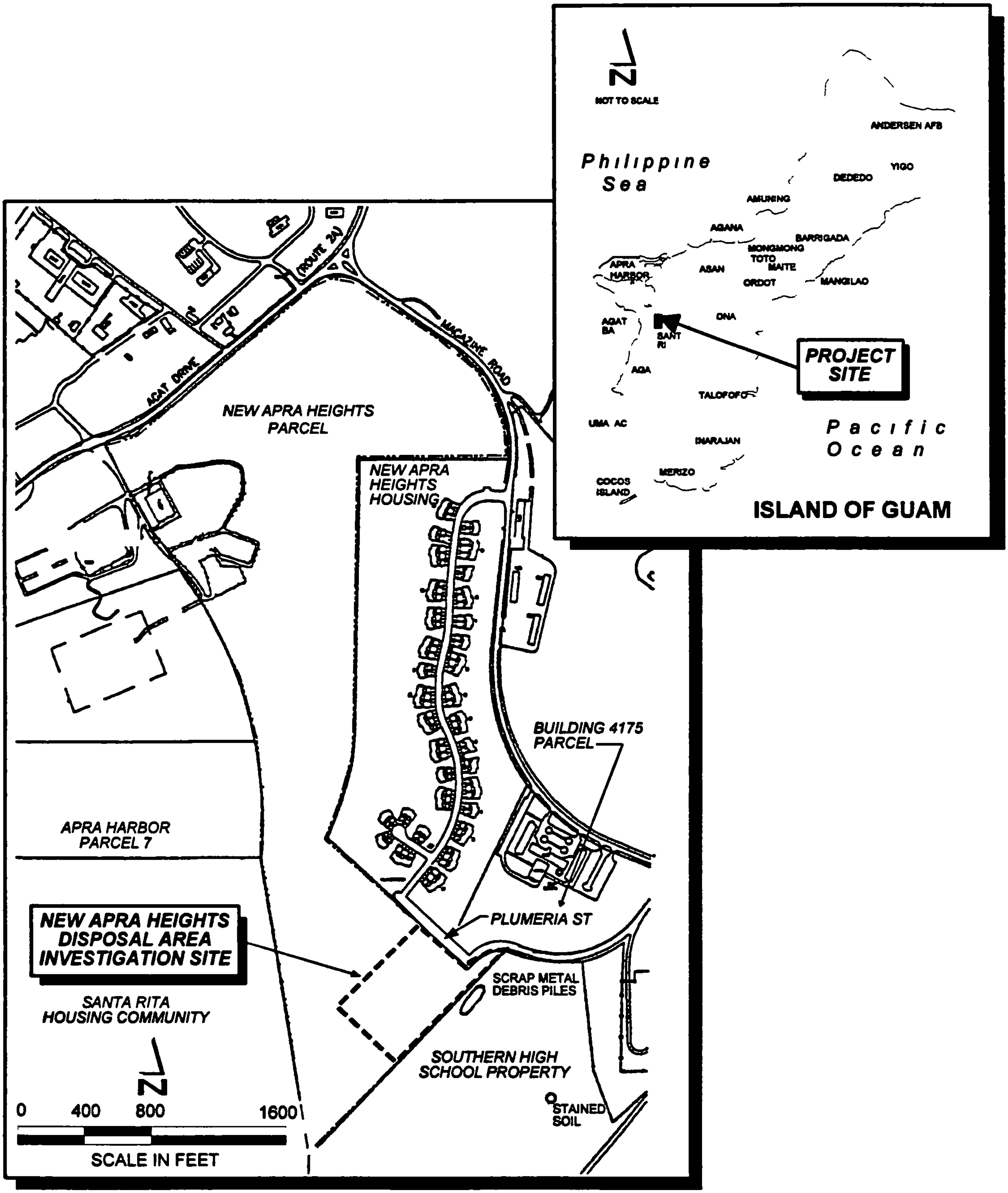
Potential pathways for migration of hazardous constituents include surface soil erosion surface water flow and leaching into the groundwater Because of the damp climate and thick vegetation air transportation of contaminated dust is not considered a concern

1 2 HISTORY OF THE SITE AND ADJACENT PROPERTY

From the 1940s to the 1970s a portion of the New Apra Heights parcel was part of Camp Busanda a former worker housing area for Public Works Center Guam Site use prior to the 1940s is not known

Northeast of the Site is the Building 4175 parcel A 1945 aerial photograph shows military tent camps on the parcel A 1954 aerial photograph portrays a parcel cleared of most vegetation but shows no signs of significant activity A 1964 aerial photograph shows Building 4175 the Bachelor Civilian Quarters (BCQ) under construction The BCQ is now used by DoD as an elementary and middle school

Figure 1 1 Site Location Map
New Apra Heights Disposal Area
Guam



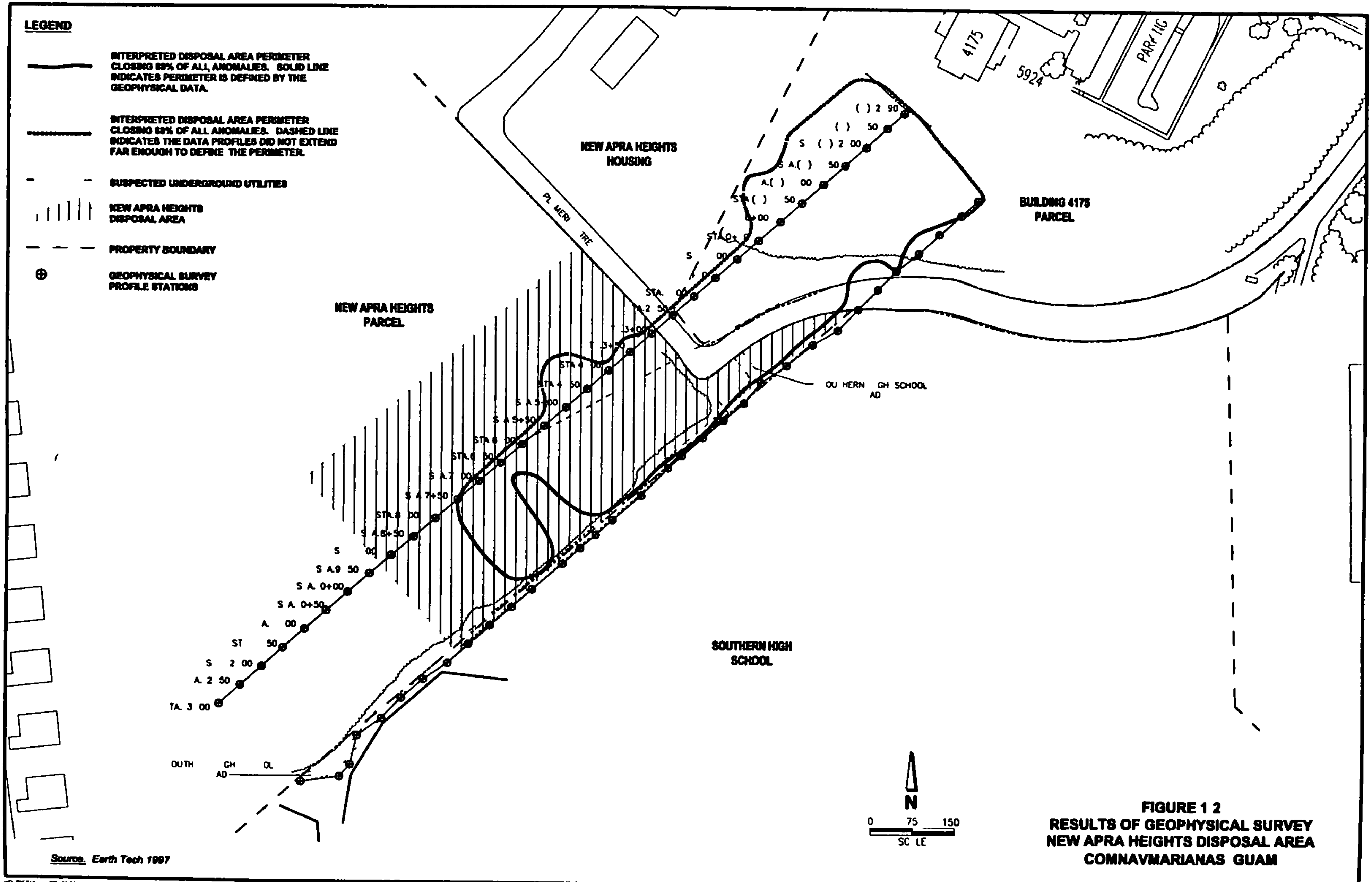


FIGURE 1 2
RESULTS OF GEOPHYSICAL SURVEY
NEW APRA HEIGHTS DISPOSAL AREA
COMNAVMARIANAS GUAM

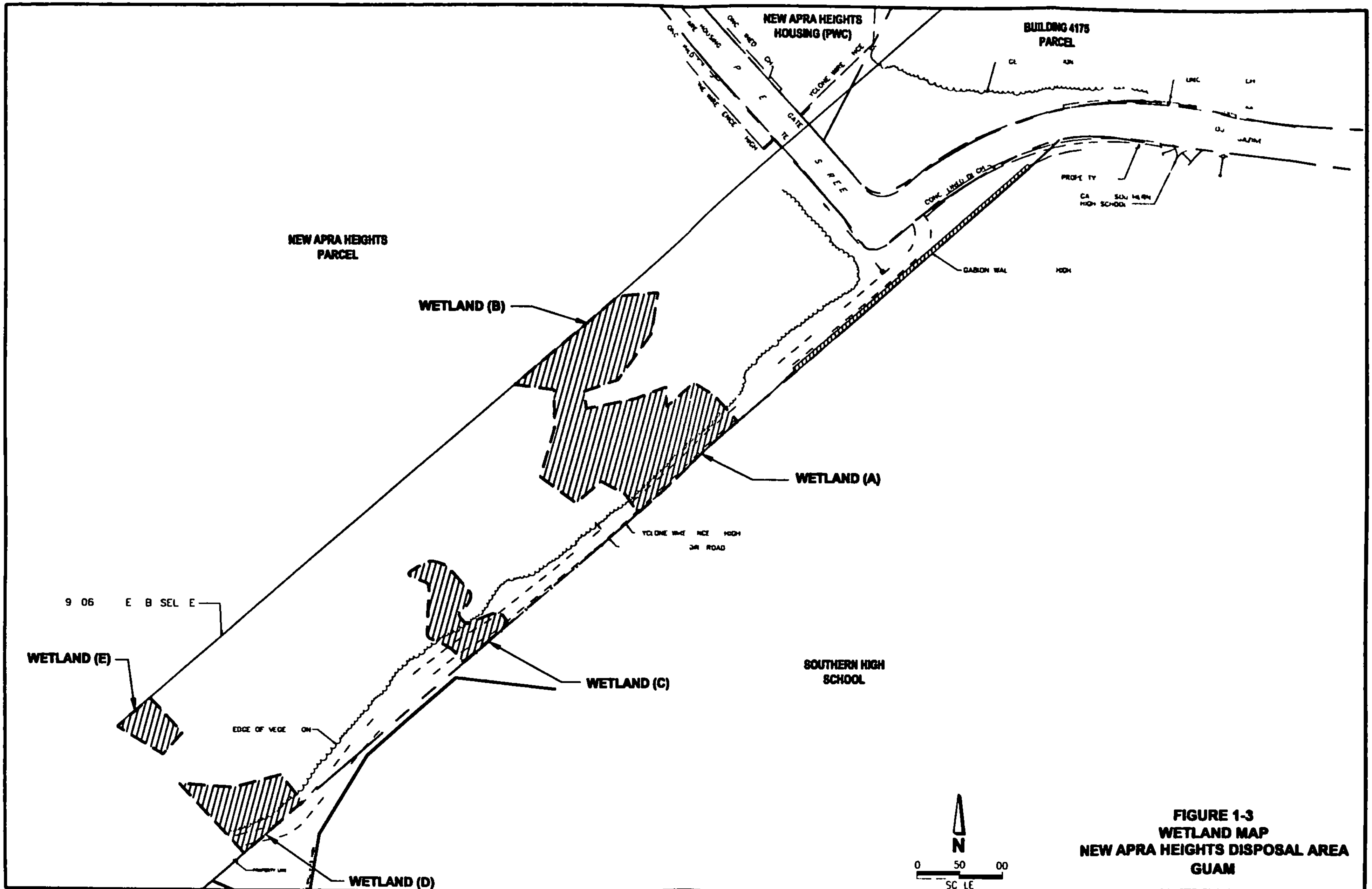


FIGURE 1-3
WETLAND MAP
NEW APRA HEIGHTS DISPOSAL AREA
GUAM

Adjacent to and south of the Site is the SHS complex, in its final stages of construction It was during this construction that subsurface debris was discovered at the complex (Ogden 1996b PBEC 1993) The property is now owned by the Government of Guam however a portion of a 15–19 foot high gabion (cobbles held together with wire mesh) retaining wall located on the SHS parcel does extend onto the Site The Government of Guam holds an easement for this portion from the Navy Historically the Site was used by the Navy s 129th Construction Battalion as a motor pool and storage yard and by the Army s 53rd Regiment as a base An Army Field Hospital may also have been located on this property The area was bulldozed for an encampment after World War II (PBEC 1993)

Improvements to the SHS infrastructure included the realignment of Plumeria Street and the construction of an access road on the New Apra Heights side of the property boundary (Figure 1 1) The gabion retaining wall and an 8 foot high cyclone wire fence delineate the boundary between the SHS complex and the New Apra Heights Disposal Area

1 3 SITE SPECIFIC OBJECTIVES

The RI has three objectives

- Determine if the Site contains levels of contamination above industrial preliminary remediation goals (PRGs)
- Characterize the nature and extent of contamination resulting from past disposal and burial practices and
- Determine the risk that contamination if detected poses to human health and the environment both onsite and offsite

1 4 PROJECT APPROACH

Metal debris possibly mixed with organic contaminants is buried at the Site A passive soil gas survey will be conducted to detect VOCs and SVOCs with relatively high vapor pressures Analytical results of this survey will be used to select soil sampling locations Trenches will be excavated to observe the characteristics of the buried debris and to sample subsurface soil Soil samples will be analyzed for VOCs SVOCs pesticides polychlorinated biphenyls (PCBs) target analyte list (TAL) metals TPH and explosives A utility survey will be conducted prior to sampling in areas that have not been surveyed See the *Sampling and Analysis Plan* (Earth Tech 1998b) for further information

2 SITE DESCRIPTION

2 1 LOCATION DEMOGRAPHY AND LAND USE

The New Apra Heights Disposal Area is situated approximately 2 miles inland of Agat Bay in the southern portion of the Island of Guam at 13 24 09 north latitude and 144 40 22 east longitude (see Figure 1 1) The Site occupies 5 3 acres (230 000 square feet) along the southeastern perimeter of the New Apra Heights subdivision Historical information and previous studies have determined that the area north of Plumeria Street is also part of the disposal area (See Figure 2 1) This RI will investigate the area south of Plumeria Street which will be referred to as the Site The Navy plans to investigate the northern portion at a later date

The Site is bordered by the following properties (see Figure 2 1)

- To the north the New Apra Heights housing operated by the Navy Public Works Center (PWC)
- To the northeast, a Navy operated elementary and intermediate school in Building 4175 The northern section of the disposal area is located on the Building 4175 parcel The building and grounds are separated from the disposal area by a 6 foot high chain link fence Surface water from the northwestern portion of the school property drains into the disposal area The Site and the portion of the disposal area located on the Building 4175 parcel are owned and operated by the Commander U S Naval Forces Marianas (COMNAVMARIANAS) Guam (formerly Naval Activities [NAVACTS])
- To the southeast, the new Southern High School (SHS) campus being developed by the Government of Guam School property is currently separated from the disposal area by a gabion wall and an 8 foot high cyclone fence
- To the southwest and northwest undeveloped land supporting natural communities of plants and animals
- To the southwest, within 1 000 feet, the Santa Rita housing community

The Site is heavily vegetated and undeveloped The southwestern third of the Site apparently was not used for waste disposal and is covered by a mixture of grassland and wetlands Areas adjacent to SHS and Plumeria Street are planted in lawn grasses maintained by mowing The Reuse Plan of the 1994 Guam Land Use Plan (GLUP) indicates future Site use will be industrial (Government of Guam 1996) A parking lot for the SHS has been considered

2 2 PHYSICAL SETTING

2 2 1 Climate

The tropical marine climate of Guam is controlled by westward moving air produced between subtropical tradewinds of the northern and southern hemispheres Weather variations are caused by continuously forming eddies or whorls in the air These disturbances are counterclockwise air flow (cyclonic) in the northern hemisphere often growing to tropical storms and typhoons On average 1 4 typhoons per year pass within 120 nautical miles of Guam There is a 1 in 5 chance that a typhoon will pass directly over Guam in a given year The likelihood of typhoons is greatest from July through September and least from January through April

Guam has two primary seasons a dry season from mid January through mid May and a rainy season from mid July through mid November Tradewinds blowing from east to northeast are the prevailing winds Tradewinds are strongest during the dry season Guam receives 80–110 inches of rainfall per year Relative humidity ranges from 65–75 percent in the afternoon to 85–100 percent at night with little seasonal variation Average annual temperature ranges between 75 and 86 degrees Fahrenheit (F)

2 2 2 Topography

The Site is situated on a volcanic soil and rock formation The volcanic region generally situated in the southern portion of the island is characterized by rolling to hilly uplands dissected by numerous deep drainage points over a resistant surface Further north the hills tend to be steeper suggesting they were islands in a prehistoric sea The New Apra Heights Disposal Area ranges in elevation from 110 to 185 feet above mean sea level (Ogden 1995)

2 2 3 Soils

The soils in the area are fine grained and cohesive and are described as predominantly clayey silt with some silty clay The Soil Survey of Guam (USDA 1988) mapped three soil types within the boundaries of New Apra Heights and the SHS (1) Akina silty clay (2) Agfayan clay and (3) Akina Badland complex These soils were derived from the underlying volcanic tuffaceous sandstones and breccias The predominant soil in the area of the Site is Akina Agfayan which is very shallow to very deep well drained moderately steep to extremely steep on strongly dissected mountains and plateaus Akina silty clay is on the Territory of Guam hydric soil list because of hydric inclusions associated with wetlands

Soil thickness at the adjacent property was as much as 19 feet in some areas Dark reddish to green clayey silts and silty clays with minor amounts of sandy gravel fill at the surface were identified in trenches at the SHS Isolated patches of limestone gravel were also found on the adjacent SHS property and were apparently used as fill during previous grading These deposits are discontinuous and usually less than 1 foot thick (PBEC 1993)

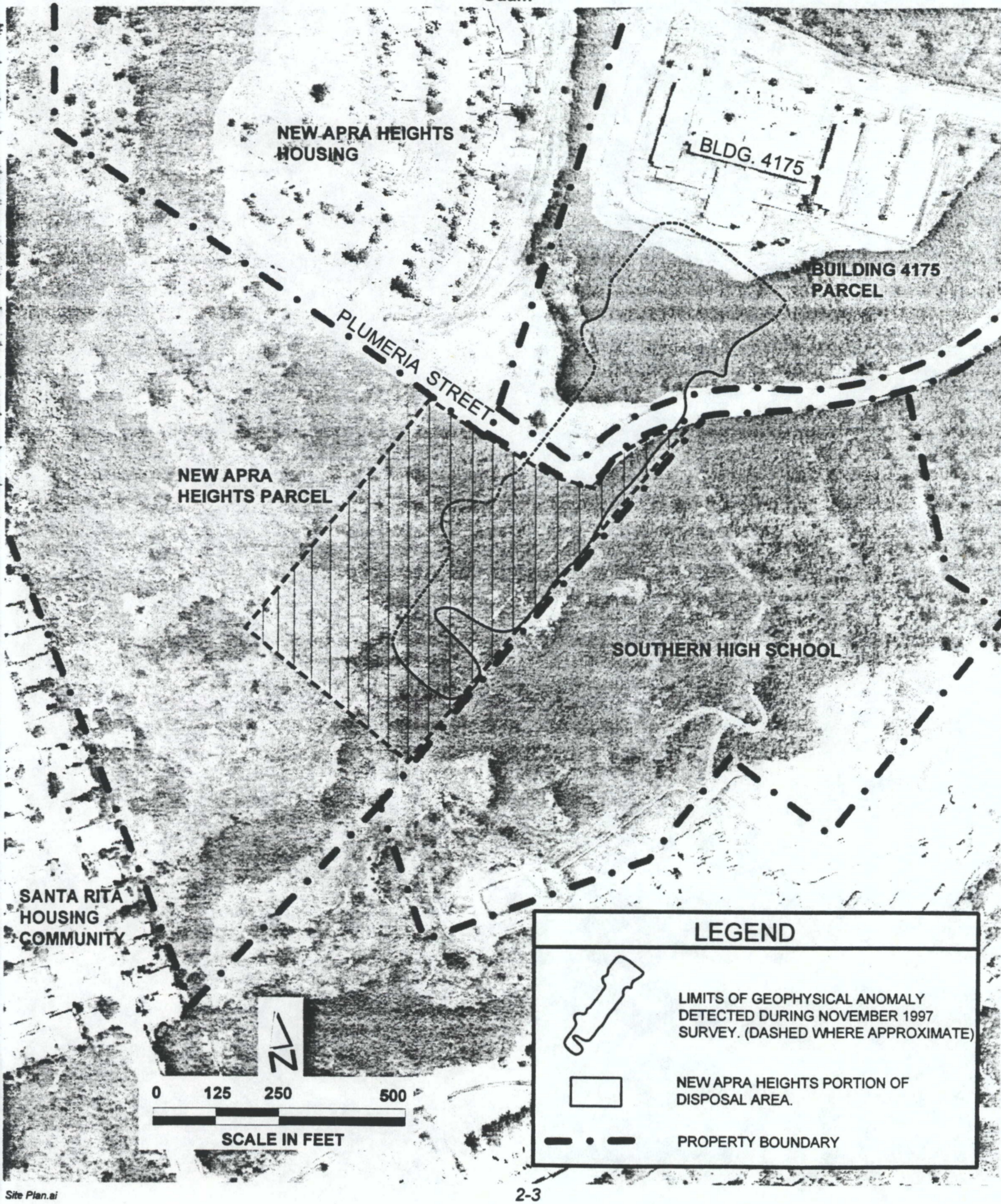
2 2 4 Geology

The island of Guam can be subdivided into four regions the northern limestone plateau interior basin coastal lowlands/alluvial valley and southern volcanic uplands The soil deposits are underlain by the Alutom formation consisting of tuffaceous shale and sandstone at depths up to about 3 feet Lenses of limestone and lava beds also characterize the geology of the region Intense folding and overthrusting of volcanic deposits occurred before the first shallow water limestones were deposited Renewed faulting followed the deposition of the first limestones creating the lines of knobs ridges and deep fissures on the island s surface Although minor movements are present along the faults the faults themselves are significant because surface water and groundwater drainages are often associated with these features A fault from central Santa Rita to the eastern New Apra Heights area was mapped trending to the northeast of the Site A conjugate fault which is unmapped is also located east of the Site

2 2 5 Hydrology

The permeability of the Alutom formation is generally low The rocks of the formation are saturated with water at variable depths but yield water slowly to wells Therefore few wells have been drilled in this area, and none have been developed for a permanent supply (PBEC 1993) Outcrops of the Alutom formation may contain perched water in weathered areas

Figure 2-1: Site Location and Properties Boundaries
New Apra Heights Disposal Area
Guam



Southern Guam gets most of its potable water from The Fena Reservoir owned and operated by the U S Navy (Ogden 1996b)

The Site is characterized by water bearing materials of volcanic rock and associated sediments The height of the water table in this region can range from a few feet above sea level in coastal lowlands to a few hundred feet above sea level in interior highlands Monitoring wells drilled in this subarea generally have low yields and high drawdowns Numerous springs and seeps may occur in valleys within this subarea Seepage was observed along the northeast bedrock cut face on the adjacent SHS site The Site is located near the surface drainage divide so there is little area for groundwater recharge above the Site (see Figure 2 2)

A Navy developed wetland less than 1 000 feet north of the Site is located in a different watershed The effect of the wetlands detected on the Site on the underlying groundwater is unknown Surface drainage and subsurface water flow across the Site toward the southwest and northwest from the northeast and southeast Surface drainage from the Site may enter the southeast corner of the Santa Rita subdivision Site influence on the subdivision was not investigated (Ogden 1996b)

2 2 6 Vegetation

Small areas adjacent to the SHS access road and Plumeria Street are developed and covered with regularly maintained grass The southwestern third of the Site is covered by a mixture of grassland and wetlands The remainder of the Site is upland habitat mixed with small wetlands Upland habitat is dominated by modified secondary forest dominated by the tangantangan tree (*Leucaena leucocephala*) an introduced species that has invaded many vegetative communities on the island The undergrowth is thick dominated by swordgrass (*Miscanthus floridulus*) Some vegetation was cleared for the geophysical survey A list of the observed and expected flora appears in Table 2 1 (Earth Tech 1998a)

2 2 7 Endangered Species and Environments

The U S Fish and Wildlife Service (USFWS) was consulted about possible adverse impacts of geophysical survey activities on federally listed endangered or threatened species The endangered Mariana common moorhen (*Gallinula chloropus guami*) a common resident of local wetlands may occur in the vicinity of the Site The USFWS stated that the survey would not affect the moorhen or other listed species adversely (Earth Tech 1997) Before conducting the RI the USFWS will be consulted on possible impacts of RI activities A list of the observed fauna appears in Table 2 2 (Earth Tech 1998a)

**Figure 2-2: Surface Drainage
New Apra Heights Disposal Area
Guam**

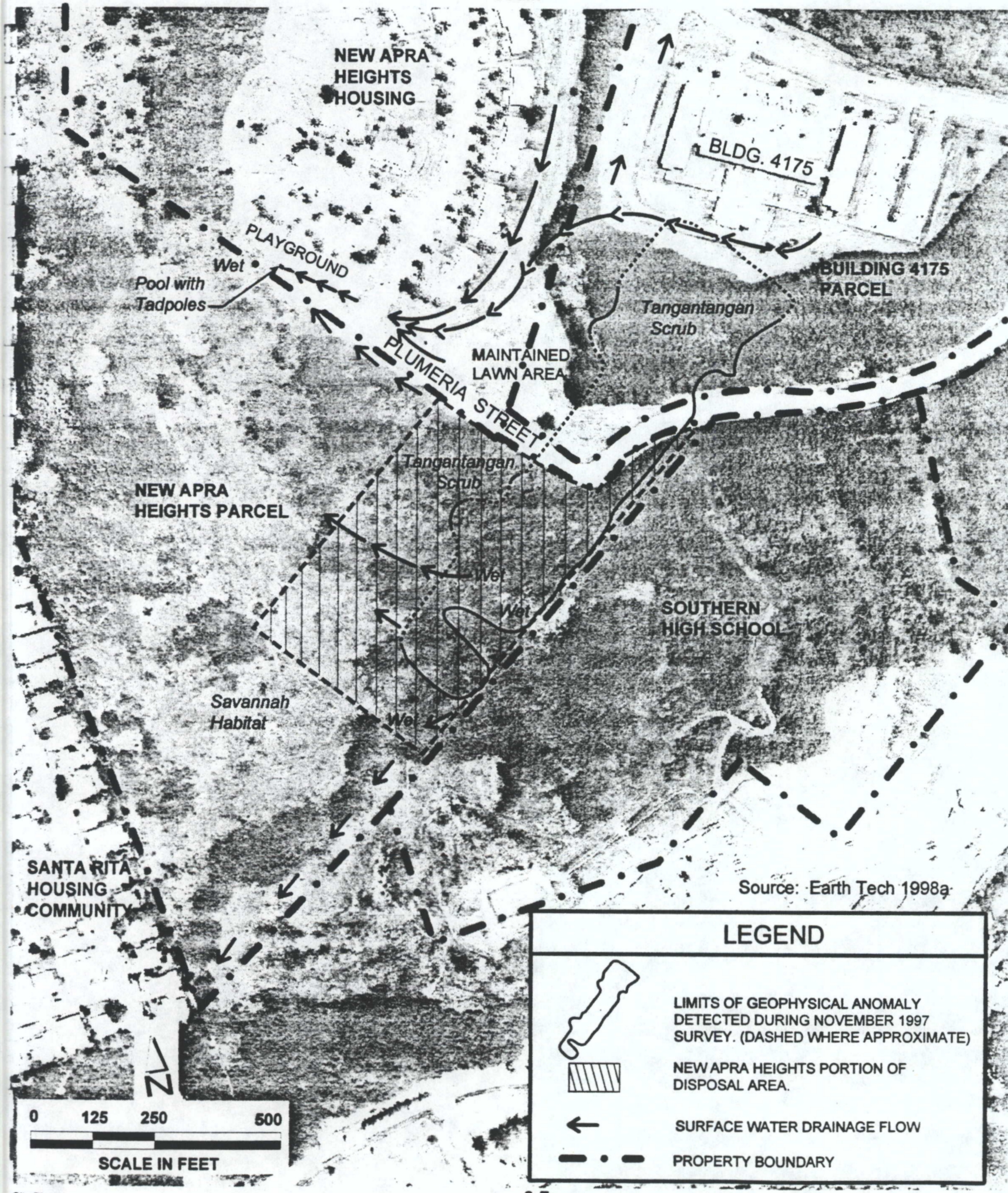


Table 2 1 Flora Observed or Expected to Occur at the Apra Heıghts Dısposal Sıte

Scıentıfic Name	Common Name	Local Name	Modıfied Secondary Forest	Savanna Communıty
Asplenıum nıdus	bırd s nest fern	Galak Dangkulo	O	—
Flagellana ındıca	false rattan	Bejuko Halumtano	O	—
Canavalıa megalantha	vıne	Akangkang	O	—
Leucanena leucocephala	—	Tangantangan	C	UC
Hıbıscus tılıaceus	hıbıscus tree	Pago	C	UC
Pandanus dubıus	pandanus screw pıne	Pahong	O	UC
Pandanus fragrans	pandanus screw pıne	Kafo	O	UC
Phymatodes scolopendna	common fern	Kahlao	C	O
Monnda cıtnfolıa	Indıan mulberry	Lada	O	O
Casuanna equısetıfolıa	ıronwood	Gago	C	O
Euphorbıa cyathophora	dwarf poınsettıa	—	UC	O
Gleıchenın lıneans	savanna fern	Mana	O	C
Dımena chlondıformıs	—	—	—	O
Mıscanthus flondulus	swordgrass	Nete	C	A
Pennısetum polystachyon	foxtaıl	—	O	C
Hyptıs capıtata	button weed	Batones	O	C
Spathoglottıs plıcata	Phılıppıne ground-orchıd	—	U	O
Passıflora suberosa	wıld passıon flower	—	C	UC
Alocasıa macromsa	wıld taro	Pıga	UC	—
Panıcum maxımum	guınea grass	—	O	—
Phragmıtes karka	reed	Karıso	O	—
Scaevola taccada	—	Nananso	O	—
Cassytha filıformıs	—	Mayagas Agası	—	O
Cocus nucıfera	coconut palm	Nıjok	C	O
Muntıngıa calabura	Panama cherry	Mansanıta	UC	—
Sıda acuta	sıda	Esco Bılla Papago	—	UC
Sıda rhombıfolıa	sıda	Esco Bılla Dalılı	UC	UC
Walthena ındıca	walthena	Esco Bılla Sabana	UC	O
Bıdens alba	beggars tıck Guam-daısy stıckleburr	—	O	O
Saccarum spontaneum	wıld cane	—	O	O
Stachytarpheta jamaıcensıs	false verbena	—	C	—

Table 2-1 Flora Observed or Expected to Occur at the Apra Heights Disposal Site

Scientific Name	Common Name	Local Name	Modified Secondary Forest	Savanna Community
Mikania scandens	mile-a minute vine	—	O	UC
Lygodium auriculatum	savanna fern	Galak	UC	C
Lygodium scandens	lygodium	Galak	UC	O
Sporobolos elongatus	rattail dropseed	—	—	UC
Davallia solida	—	Pugua Machena	C	—
Passiflora foetida	Love in a Mist	Kinahulo Atdao	C	UC
Pancratium littorale	spider lily	Lirio	UC	—

Habitat Types S = Savanna M = Modified Secondary Forest
Relative Abundance A = Abundant C = Common
O = Occasional UC = Uncommon
NF = Not Found

Table 2-2 Fauna Observed on the Apra Heights Disposal Site

Scientific Name	Common Name	Local Name	Relative Abundance
Invertebrates			
Eisenia fetida	earthworm	Akehehá	C
Achitina fulica	African land snail	Akalehá	UC
Camaenid sp	land snail	—	UC
Cyrtophora mollucensis	tent spider	Sanyéyé	C
Amphibians			
Bufo marinus	marine toad	Tot	C
Reptiles			
Lepidodactylus lugubris	mourning gecko	Gualiek	C
Carlia fusca	four toed skink	Achiak	C
Emoia caeruleocauda	blue-tailed skink	Achíak	C
Birds			
Dicrurus macrocercus	black drongo	Salen Taiwan	UC
Ixobrychus sinensis	yellow bittern	Kakkak	UC
Passer montanus	Eurasian tree sparrow	Chichirika	UC
Streptopelia bitorquata	Philippine turtle dove	Paluman Sinisa	UC
Mammals			
Canis familiaris	feral dog	boonie dog	UC

Relative Abundance A = Abundant C = Common UC = Uncommon

3 INITIAL EVALUATION

3 1 IDENTIFICATION OF CONTAMINANT SOURCES AND TYPES AND VOLUMES OF WASTE DISPOSED

As part of an SI conducted in 1995 by Ogden soil gas and surface and subsurface soil were sampled throughout the SHS site to assess the nature and extent of contaminants encountered during construction Samples were also collected from offsite locations where soils excavated from the SHS site were deposited Samples were analyzed for TPH VOCs SVOCs chlorinated pesticides and PCBs and TAL metals

Surface soil samples contained elevated levels of TPH PAHs and metals however these contaminants were found almost exclusively within the scrap metal pile which was reportedly removed from the Site Total TPH concentrations from the scrap metal pile averaged 163 mg/kg while total TPH concentrations for the rest of the SHS site averaged 36 mg/kg PAHs were also found in all samples collected from the scrap metal pile PAHs were detected at a maximum estimated concentration of 630 µg/kg Scrap metal pile samples also contained the metals antimony arsenic cadmium lead and zinc at concentrations above the established background level for the SHS site (Ogden 1995) Subsurface soil samples were also collected from trenches located at the fuel and oil storage areas and at the southwestern corner of the SHS site Several of the trenches contained scrap metal debris including crushed 55 gallon drums Analysis of subsurface trench soil samples yielded similar results to those of surface soil samples Elevated concentrations of TPH PAHs and metals were detected in soil samples collected from near the pile Two trench soil samples yielded concentrations of TPH greater than 20 mg/kg and also contained metals PAHs were detected in only one trench soil sample

A thick yellow white substance was discovered inside a crushed 55 gallon drum that was found in a trench Analysis of this substance yielded barium cadmium and selenium at concentrations ranging from 0 02 to 0 15 mg/L Methylphenol the only organic compound detected in the substance was found at an estimated concentration of 0 15 mg/L The substance was assumed to be some sort of adhesive based on odor and visual characteristics The highest concentrations of TPH VOCs SVOCs pesticides and TAL metals were detected in soil samples collected from the 26 foot high mound Organic compounds and TPH were all found at high levels in comparison to on site and off site soil at the SHS site Minor concentrations of explosive residues were also found in soil samples collected from the SHS site The soils found to contain the highest concentrations of contaminants were darkly stained and wet with a strong odor of hydrocarbons

3 2 CONCEPTUAL EVALUATION MODEL

The conceptual evaluation model (CEM) provides a framework for assessing the condition of a site based on the relationship between sources of contamination and receptors exposed to the contamination The completeness of information in this framework aids in identifying data needs The CEM identifies contaminant sources and types (Section 3 2 1) mechanisms contaminant transport from sources (Section 3 2 2) potential human and ecological receptors of transported contaminants (Section 3 2 3) and pathways for human and ecological exposure to contaminants (Section 3 2 4)

Initial evaluation of existing data provides the following

A CEM describing contaminant transport from sources pathways for human and ecological receptor exposure to contaminants and potential receptors of transported contaminants

- A prelımınary assessment of human health and ecological nsk
- A summary of data needs and
- A prelımınary ıdentıficatıon of applıcable or relevant and appropnate requırements (ARARs) and to-be consıdered materıal (TBCs)

The results of thıs ınıtıal evaluatıon coupled wıth the RI objectıves outlıned ın Sectıon 1 led to the development of the RI technıcal approach presented ın Sectıon 4

The prelımınary human health and ecologıcal rısk assessment ıs lımıted to ıdentıfyıng potentıally exposed receptors Sıte related contamınants pose rısk to receptors ıf the transport and exposure pathway ıs complete The CEM descrıbes the completeness or ıncompleteness of the exposure pathway

The physıcal demographıc ecologıcal and chemıcal ınformatıon from prevıous ınvestıgatıons were evaluated to develop the CEM for the Sıte The CEM for the Sıte ıs a dynamıc model that ıs revısed to ınclude or exclude sources receptors or exposure pathways as addıtıonal data become avaılable from the RI (see Fıgure 3 1 and Fıgure 3 2)

The prelımınary CEM The prelımınary CEM ıs based on the followıng ınformatıon Currently the Sıte ıs owned by the U S Navy and ıs undeveloped As shown ın Fıgure 2 1 surroundıng land uses ınclude

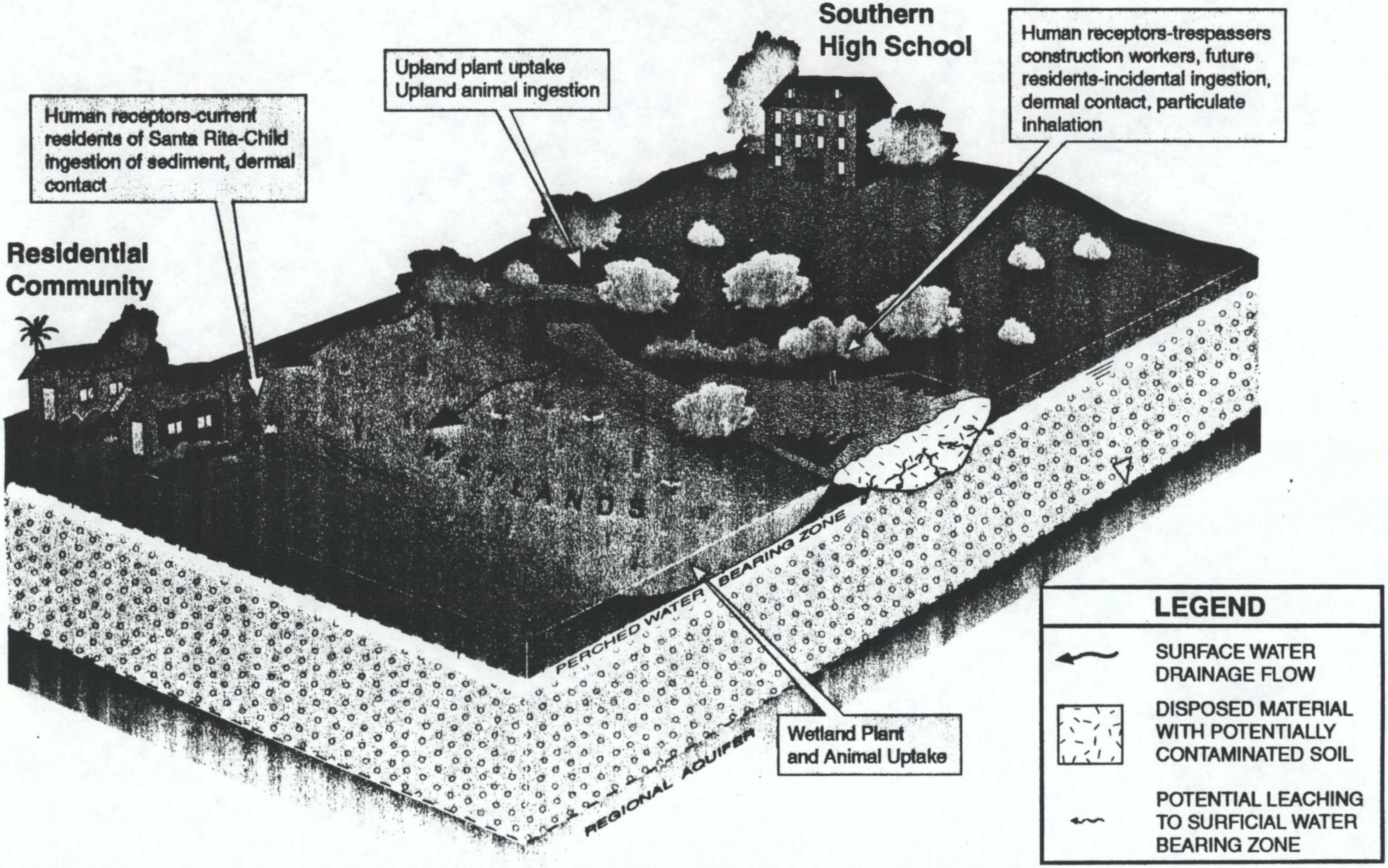
- The SHS southeast and topographıcally upgradıent of the Sıte
- New Apra Heıghts housıng
- Navy operated elementary and ıntermedıate school ın Buıldıng 4175
- Santa Rıta housıng development southwest and down gradıent of the Sıte and
- Undeveloped land wıth wetland savanna, and Tangantangan scrub woodland habıtat located southwest and downgradıent (ı e northwest) of the Sıte

The Sıte slopes generally from east to west Past dısposal appears to have occurred prımarıly ın the northeastern portıon of the Sıte Based on observatıons made durıng the bıologıcal reconnaıssance water draıns from thıs portıon of Sıte to the west and south where a mosaıc of wetland and upland habıtat ıs present The wetlands receıve surface runoff of water and sedıment from the dısposal area Shallow groundwater from the Sıte may also dıscharge to the wetlands Part of the wetland complex draıns south to the Santa Rıta housıng area

3 2 1 Contamınant Sources and Types

Table 3 1 lısts the chemıcals of potentıal concern (COPCs) based on Sıte hıstory and the analytıcal results of prevıous ınvestıgatıons of the adjacent SHS sıte

Figure 3.1
Exposure Pathways and Receptors
New Apra Heights Disposal Area



Contaminant Source	Transport Mechanism	Exposure Route	Receptors: Current Use – Trespassers (Adult/Child)	Receptors: Current Use – Ecological Receptors	Receptors: Future Use – Onsite Residents (Adult/Child)	Receptors: Future Use – Ecological Receptors	Rationale/Data Needs
Surface Soil	Direct Contact	Dermal Absorption	Potentially Complete	Potentially Complete	Potentially Complete	Potentially Complete	Direct contact with surface soil potentially complete for current trespassers future industrial workers and ecological receptors Surface Soil data are needed to assess pathways
		Incidental Ingestion	Potentially Complete	Potentially Complete	Potentially Complete	Potentially Complete	
	Air Transport	Inhalation of VOCs	Insignificant	Insignificant	Potentially Complete	Insignificant	Air pathway insignificant for all current trespassers because of low exposure frequency and dilution Heavy vegetation prevents current fugitive dust generation so no inhalation or deposition pathway Surface soil data will provide information to assess future exposure to onsite industrial workers
		Inhalation of Particulates	Insignificant	Insignificant	Potentially Complete	Insignificant	
	Surface Water Runoff/ Discharge to Wetlands	Dermal Absorption	Insignificant	Potentially Complete	Incomplete	Potentially Complete	Surface water runoff and discharge to the wetlands is potentially complete assuming there is surficial contamination Bioaccumulation is insignificant for trespassers Surface soil data are needed to assess current and future exposure to ecological receptors
		Incidental Ingestion	Insignificant	Potentially Complete	Incomplete	Potentially Complete	
		Inhalation of VOCs	Insignificant	Insignificant	Insignificant	Insignificant	
		Bio-accumulation/ Consumption of Fish and Vegetation	Insignificant	Potentially Complete	Incomplete	Potentially Complete	

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Figure 3 2 Conceptual Evaluation Model, New Apra Heights Disposal Area

Contaminant Source	Transport Mechanism	Exposure Route	Receptors: Current Use: Trespassers (Adult/Child)	Receptors: Current Use: Ecological Receptors	Receptors: Future Use: Onsite Residents (Adult/Child)	Receptors: Future Use: Ecological Receptors	Rationale/Data Needs
Subsurface Soil	Unsaturated/ Saturated Zone Transport to Groundwater and Discharge to Wetland	Dermal Absorption	Insignificant	Potentially Complete	Incomplete	Potentially Complete	Exposure to groundwater seeps by trespassing human receptors considered insignificant due to low exposure frequency and dilution/attenuation of contaminants Ecological receptors may be exposed to seepage after it discharges to surface water/sediment Groundwater underlying the site is not used for drinking water or irrigation purposes Subsurface soil data are needed to assess potentially complete exposure pathways for ecological receptors
		Incidental Ingestion	Insignificant	Potentially Complete	Incomplete	Potentially Complete	
		Inhalation of VOCs	Insignificant	Insignificant	Insignificant	Insignificant	
		Bio-accumulation/ Consumption of Fish and Vegetation	Incomplete	Potentially Complete	Incomplete	Potentially Complete	
		Drinking Water	Incomplete	Potentially Complete			

Figure 3 2 Conceptual Evaluation Model New Apra Heights Disposal Area (Continued)

Table 3-1 Chemicals of Potential Concern

Chemical	Range
Total Petroleum Hydrocarbons (TPH)	173–5 130 mg/kg
Volatile Organic Compounds (VOCs)	7 000–16 000J µg/L
Semi Volatile Organic Compounds (SVOCs)	6 900–270 000J µg/L
Metals	1 87–730 mg/kg
Pesticides	5 9–1 580 µg/kg
Explosives	120–160 mg/kg

Source Ogden (1995)
J Concentrations should be considered estimated because the reported value was less than the contract required quantitation limit
mg/kg = milligram per kilogram
µg/kg = microgram per kilogram

3 2 2 Contaminant Transport and Fate

After a chemical is released to the environment, it may be retained in one or more media, including the receiving medium or be transported to other media The movement or retention of contaminants is conceptually referred to as the 'transport mechanism For example contaminants released to soil may be taken up by plants or animals the uptake of contaminants is a transport mechanism for soil contaminants

The transport of contaminants creates other sources of contamination For example if contaminants in unsaturated subsurface soil migrate to groundwater in the pure phase (product) vapor phase (soil gas) or dissolved phase (leaching) then groundwater becomes a source of contamination The CEM considers these potential sources of contamination for the Site

3 2 3 Human and Ecological Receptors

Potential human receptors include trespassers Potential ecological receptors include terrestrial and wetland plants and animals Potential exposure pathways include incidental ingestion of surface soil and dermal soil contact for human and terrestrial animal receptors and food web exposure for terrestrial animals Because of the damp climate and thick vegetation at the Site air transportation of contaminated dust is not expected to be a concern Terrestrial plants could be exposed via root uptake from surface soil Wetland plants and animals could be exposed via uptake from contaminated surface water and sediment

The Site will be transferred from the Navy under the BRAC Future land use of the property will be industrial as specified in the GLUP 1994 land use plan (Government of Guam 1996) Potential future human receptors include industrial workers and trespassers The exposure pathways could include incidental ingestion of surface soil dermal soil contact, and inhalation of VOCs Future exposure pathways for ecological receptors via surface soil are similar to current pathways

3 2 4 Exposure Pathways

Exposure pathway assessment is based on (1) source and release mechanism (2) transport mechanism (3) exposure point, and (4) exposure route The CEM which considers all of these elements uses historical data and observations made during the RI the geophysical survey biological reconnaissance and wetland delineation This CEM will be updated during the RI in response to new information

Potential pathways for migration of hazardous constituents include surface soil erosion surface water flow and leaching into the groundwater Because of the damp climate and thick vegetation air transportation of contaminated dust is not considered a concern

Soil Pathway Onsite receptors may be exposed to contaminants retained in surface soil through two exposure routes dermal contact or incidental ingestion Dermal contact or incidental ingestion of surface soil requires direct contact with the surface soil on the Site Therefore offsite receptors are not exposed to contaminants retained in surface soil through dermal contact or incidental ingestion

Onsite and offsite receptors may be exposed to contaminants taken up from soil by plants/animals by ingesting the plants and/or animals Plant uptake of contaminants in soil occurs through the root zone between the ground surface and approximately 3 feet below ground surface (bgs)

Surface Water Flow Onsite receptors may be exposed to contaminants in surface water runoff through incidental ingestion and/or dermal contact However incidental ingestion of surface water is unlikely and dermal contact is infrequent and/or of short duration Therefore this exposure route is assumed to be incomplete or insignificant for onsite and offsite receptors

Groundwater Pathway The shallow water bearing zone and deeper groundwater aquifer are not used for domestic purposes All existing housing in the disposal area vicinity is served by municipal water and sewerage This water supply system is expected to be expanded to include all new development in the area Therefore there is no current, and probably no future exposure to potentially contaminated groundwater Ecological receptors are generally not exposed to groundwater unless it discharges to the surface

3 3 Identification of Data Needs

Limited field data have been collected within the site boundary To achieve the objectives of the RI field data are needed to

- Verify presence of potential onsite contamination sources
- Assess the nature of contamination if found onsite
- Provide a preliminary evaluation of the extent of the contamination if found onsite
- Enable preliminary evaluation of the potential human health and ecological risks posed by the Site and
- Determine if contaminants are migrating offsite

3 4 Site Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Materials

3 4 1 Definitions

Navy policy is that all actions carried out under the Installation Restoration program be consistent with Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (as amended by Superfund Amendments and Reauthorization Act [SARA] and the National Oil and

Hazardous Substances Pollution Contingency Plan [NCP]) in Title 40 of the Code of Federal Regulations Part 300 CERCLA requires cleanup response actions to

1 Protect human health and the environment

2 Be cost effective and

3 Comply with ARARs and TBCs

The ARARs and TBCs that govern actions at CERCLA sites fall into three categories based on the chemical contaminants site characteristics and location and proposed cleanup activity Chemical specific ARARs and TBCs establish numerical standards limiting the concentration of substances in the medium of concern or medium affected by the cleanup action Location specific ARARs and TBCs refer to restrictions placed on the concentration of substances or conduct of the cleanup action due to site location Action specific deals with technology or activity based restrictions controlling the performance and design standards of a specific cleanup action

Requirements may be applicable or relevant and appropriate Applicable requirements are federal or state standards by which Site activity (sampling cleanup etc) is regulated These requirements meet legal prerequisites that concern the circumstances and conditions at the site Applicable requirements identification will include

Regulatory authority and the statute or regulation

Types of activities the statute or regulation requires directs or prohibits

Types of substances or activities falling under the authority of the requirement and

Time period for which the statute or regulation is in effect

When requirements are not directly applicable to a site or activity they may still be appropriate and relevant Requirements are appropriate and relevant if they pertain to problems similar in nature to circumstances at the site These requirements are identified by first comparing the site circumstances and the requirements of a particular jurisdiction then determining whether the two are sufficiently similar The determination of relevant and appropriate requirements is made with some discretion Some of the factors for determination include

- Type of cleanup action

Contaminants present

Waste characteristics and

Physical characteristics of the site

It is possible for only a part of a requirement to be considered relevant and appropriate

TBCs are advisory they are not mandated by government Typically TBCs are used when no ARARs exist to apply to certain situations or circumstances They may also be used to set ARARs when those ARARs are not sufficient to protect human health or the environment For cleanup activities TBCs can become standards which need to be complied with by the proposed cleanup remedy The application of TBCs is subject to discretion and is not required

Tables have been developed to outline and define ARARs and TBCs relevant to the Site The tables correspond to chemical specific (Table 3 2) location specific (Table 3 3) and action specific (Table 3 4) ARARs

Table 3-2 Chemical Specific ARARs and TBCs

ARAR/TBC	Requirement Description	Citation	Status
Health Based Guidelines for Soil Based on Direct Contact	Generic criteria used to evaluate which contaminants are present in surface soils at concentrations that warrant further assessment	U S Environmental Protection Agency (USEPA) Region IX PRGs second half of 1997	TBC
Human Health Risk Assessment Levels of Concern	Human health risk assessment-derived concentrations	None	TBC
Migration Guidelines	Soil Screening Levels consist of chemical soil concentrations used to determine the potential for migration of contaminants from soil to groundwater	USEPA Region IX Soil Screening Levels (SSLs) Second half of 1997	TBC

Table 3-3 Location Specific ARARs and TBCs

ARAR/TBC	Requirement/ Description	Citation	Status
Clean Water Act	Any site investigation or remediation action that may involve dredging or filling a wetland area requires a permit issued by the state or federal government For CERCLA sites permits are not required but all substantive requirements of the Act must be followed	33 USC 1251 Clean Water Act 404	ARAR
Guam Soil Erosion and Sedimentation Control Regulations	Provisions impose requirements on earth-moving activities which create a danger of accelerated erosion and which require planning and implementation of effective soil conservation measures	Section I Subsection F Section XI Subsection A	ARAR
Preservation and Enhancement of Wetlands	The management and protection of wetland areas shall be taken into consideration and incorporated into the decision making process whenever proposed actions may have an impact upon those areas	40 CFR 6 Appendix A	ARAR

Table 3-4 Action Specific ARARs and TBCs

ARAR/TBC	Requirement/Description	Citation	Status
Resource Conservation and Recovery Act Hazardous Land Disposal	This requirement regulates the hazardous substances contained in the IDW not the IDW itself The regulations govern how the IDW will be handled and disposed	40 CFR Part 261	ARAR

IDW = investigation-derived waste

3 4 2 Chemical Specific ARARS/TBCs

No known chemical specific ARARs dealing with soil contamination at the Site exist TBCs must be used as the guidelines or standards associated with planned activities at the Site

U S Environmental Protection Agency (USEPA) Region IX Preliminary Remediation Goals USEPA Region IX PRGs are chemical specific goals set by the USEPA as health based TBCs USEPA uses standard defaults for calculations These values include exposure frequency duration receptor sensitivity and chemical physical and toxicological characteristics of contaminants The estimates provided by the USEPA are considered conservative and are used to calculate risk of potential contamination from these compounds under site specific conditions The PRG contaminant concentrations are derived from carcinogenic or systemic toxicity when inhaled ingested or absorbed through the skin

At present, the Site is inactive There is no work being conducted at the Site and access has been restricted Therefore potential exposure due to land use is not of concern Because future land use for industrial purposes is planned by the Government of Guam (1996) the industrial PRG values shall be used as screening criteria The PRG list is a conservative estimate of potential human health risk Exposure to concentrations at or below those given in the PRG list is classified as a minimal health risk Actual cleanup concentrations may be as much as 100–1 000 times higher than PRGs

The USEPA Region IX PRG list will be used as chemical specific TBCs for surface and subsurface soils Because the federal PRGs are health based figures they are only relevant for surface soil samples and are based on direct contact by receptors

Human Health Risk Assessment A human health risk assessment (HRA) will be conducted as described in Section 5 6 if contaminants are detected Levels of concern will be calculated for contaminants dected

USEPA Soil Screening Levels (SSLs) USEPA SSLs provide values for chemical concentrations that estimate the potential for contaminant migration from soil to groundwater The SSLs are generic values calculated using default values in standardized equations They were developed using a dilution attenuation factor (DAF) to account for natural processes that reduce contaminant concentrations in the subsurface There are also generic SSLs that assume no dilution or attenuation between the source and the receptor

3 4 3 Location Specific ARARs/TBCs

Location specific ARARs and TBCs restrict soil concentration levels and activities conducted at the Site because of the Site location

Clean Water Act Section 404 Wetlands located on the Site are (Earth Tech 1998a) protected by Section 404 of the Clean Water Act (CWA) which regulates activities adversely affecting federally protected wetlands As a CERCLA site the Site is exempt from the permit requirements that normally apply to site investigations or remedial actions conducted in or around wetlands Nonetheless investigators must comply with the substantive requirements of the regulations To the extent possible no activities will be conducted to adversely impact the wetlands Some RI activities will qualify for permitting under one or more nationwide permits These activities will comply with applicable nationwide permit conditions

Guam Soil Erosion and Sedimentation Control Regulations Guam regulations were designed to protect the wetlands streams and marine waters of Guam The planned excavation work will be conducted in the proximity of two wetland areas and does present the possibility of soil erosion and sedimentation affecting the purity of the wetland areas The provisions of these regulations impose requirements on earth moving activities that can create accelerated erosion or the danger of accelerated erosion As such soil conservation measures must be effectively planned and implemented Regulations set forth requirements for the control of grading clearing and grubbing and stockpiling set limits for erosion and sedimentation establish administrative procedures and minimum requirements for issuance of permits and provide for the enforcement of such rules and regulations The purpose of the RI is considered exploratory excavations for the purpose of soils testing and therefore exempt under Section I Part F subpart f of the Guam Environmental Protection Agency regulations

Preservation and Enhancement of Wetlands (40 CFR 6 Appendix A) Wetland and flood plain management and protection goals must be incorporated into the planning regulatory and decision making processes when an activity is planned at a site where wetlands are present It also promotes the preservation and restoration of wetland and flood plain areas so their natural and beneficial values can be realized All wetland areas in the proximity of the Site will be avoided if possible

3 4 4 Action Specific ARARs/TBCs

Action specific ARARs/TBCs refer to technology or activity based requirements or regulated actions taken with respect to hazardous waste Because no remedial actions are currently planned no action specific ARARs or TBCs other than those related to investigation derived waste (IDW) have been identified If necessary action specific ARARs and TBCs will be identified prior to conducting further response activities

Management of Investigation Derived Waste IDW which may include soil decontamination fluids (water detergent water) and disposable sampling and personal protective equipment will be managed and handled according to its characteristics There are no regulations specifically pertaining to IDW but Resource Conservation and Recovery Act of 1976 (RCRA) regulations may cover the constituents within the IDW

Title 40 of the Code of Federal Regulations Part 261 establishes basic definitions of solid and hazardous waste Waste materials that may be generated from the RI will be characterized for disposal offsite

4 RI RATIONALE

4 1 APPROACH

A two-phased approach will be used to achieve the objectives of the RI as outlined in Section 1 3 During the first phase a passive soil gas survey will detect VOCs and relatively volatile SVOCs that are possibly commingled with the metal debris detected during the geophysical survey Passive soil gas samples will be taken using a triangular grid described in the SAP (Earth Tech 1998b) and in Section 4 2 below Three additional samples will be taken from the wedge shaped section northeast of the Site between Plumeria Street and the gabion wall

During the second phase surface and subsurface soil samples will be collected from predetermined locations along a triangular grid as described in the SAP (Earth Tech 1998b) One additional surface and one subsurface soil samples will be taken from the wedge shaped section northeast of the site Soil gas data will be used to adjust surface and subsurface soil sampling locations The soil samples will be analyzed for TPH VOCs SVOCs chlorinated pesticides and PCBs explosives and TAL metals

A limited number of surface soil samples (approximately five) will also be collected from low lying areas suspected to receive runoff from the Site and will be analyzed for the Site COPCs These samples will be in addition to those collected along the triangular grid Data from these samples will be used to assess the potential for contaminants to have migrated from the Site

4 2 DATA QUALITY OBJECTIVES

The overall sampling and analysis strategy presented herein was developed using the USEPA Data Quality Objectives Process (USEPA 1994) an effective structure for characterizing project resources and constraints The DQO process identifies decision makers the resources available and the purpose of the study describes how decisions will be made and refines the sampling design using inputs from the stakeholders

The U S Navy is conducting the RI in support of property transfer under the BRAC Act Previous investigations indicate that contamination may be present and that further evaluation is warranted The RI will collect soil gas surface soil and subsurface soil samples Sampling and analysis data must be gathered to determine contamination levels and human health or ecological risk The primary decision maker in this process will be the BRAC Cleanup Team (BCT) consisting of representatives from the Navy USEPA Region IX and Guam EPA

4 2 1 Statement of the Problem

Previous investigations at the SHS and the Site identified buried debris and chemical contamination TPH VOCs SVOCs pesticides and PCBs explosives and TAL metals have been detected at the SHS and are Site COPCs A geophysical study at the Site surveyed an anomaly consisting of buried debris

BRAC requires the Site to be investigated and if necessary cleaned up before the property is transferred PACNAVFACENGCOM will investigate the Site in accordance with the presidential mandate "Fast Track Cleanup at Closing Installations" to determine the nature and extent of environmental contamination resulting from past disposal and burial practices

Information required includes the identity concentration location and distribution of COPCs Results of the field investigation will be used to further refine the CEM and to perform a screening risk assessment

4 2 2 Identification of the Decision

The following decisions will be made based on the data gathered during the RI and incorporated into the RI conclusions

Do COPCs exceed ARARs or TBCs identified?

Does the Site pose an unacceptable risk to human health or the environment?

4 2 3 Identification of Inputs to the Decision

Soil gas and surface and subsurface soil samples will be collected and analyzed for the Site COPCs Summaries of proposed activities that will be conducted are included below Details of the planned activities are included in the SAP (Earth Tech 1998b)

One hundred eighteen passive soil gas samples will be collected based on a 625 foot by 400 foot triangular grid and 3 passive soil gas samples will be collected from the wedge shaped section northeast of the grid Samples will be analyzed for VOCs and SVOCs These data will be used to further refine the soil sampling plan

Twenty surface soil samples will be collected along a 500 foot by 300 foot triangular grid and analyzed for TPH VOCs SVOCs chlorinated pesticides PCBs explosive residues and TAL metals One surface soil sample will be collected from the wedge shaped section northeast of the site and analyzed for the same list of contaminants

Twenty one trenches will be excavated to characterize subsurface conditions and collect subsurface soil samples These samples will be analyzed for the same parameters as the surface soil samples Proposed trench locations will be at the same locations as the surface soil samples

Five surface soil samples will be collected from low lying areas located adjacent to the disposal area These samples will be analyzed for the same parameters as the other surface and trench soil samples Results from the analysis of these samples will be used to assess the potential for offsite contaminant migration

Other decision making inputs are as follows

Identity and concentrations of environmentally significant contaminants at adjacent sites either through knowledge of historic use or identification in previous Site samples

Characterization of the concentrations of naturally occurring analytes in background locations based on previous environmental investigations and soil survey data (USDA 1988)

4 2 4 Definition of Study Boundaries

This RI addresses only the portion of the disposal area located within the New Apra Heights parcel (i e the area southwest of Plumeria Street and northwest of the gabion wall) The portion of the disposal area located on the Building 4175 parcel (north of Plumeria Street) will be addressed by the Navy in a separate study

Surface soil samples will be collected from the first 6 inches of the soil One subsurface soil sample will be collected from each excavated trench at depths dependent on the distribution of buried debris The horizontal and vertical limits of the Site will be dependent on the depth of debris and extent of contamination The limits of the study will be expanded if necessary to assess contamination detected during the RI

Due to Guam s remote location the difficulty of transporting samples may cause analytical sample holding times to be exceeded Special care will be taken to properly containerize and ship the samples

Guam has two primary seasons dry and rainy Probably the most unbiased samples can be obtained between the end of May and the middle of July during the transition period and before the start of the rainy season The time frame for the RI field investigation approximately June 1998 to July 1998 coincides with this time frame

4 2 5 Summary of Decision Rules

Decision making will be based on validated data Laboratory contaminants or artifacts of sampling shipping or analysis will be removed from consideration

The data gathered from this study will be compared to ARARs and TBCs or risk based thresholds These criteria or decision thresholds are described below for the three groups of samples to be collected Project decision threshold values are shown in Table 3 1 of the QAPP Analytes exceeding these decision threshold values will initiate further response actions Analytes not detected or at concentrations below these values will be removed from further consideration

Some analytical detection limits are recognized to be above the established decision thresholds In these cases in the absence of other data (previous detection historical usage known degradation byproducts of confirmed releases etc) suggesting the presence of those analytes as chemicals of concern the default decision threshold will be one half of the laboratory reported detection limit

4 2 6 Limits of Decision Error

The RI sampling plan is intended to efficiently and cost effectively investigate the Site by covering the largest area possible with the fewest number of samples Soil gas and surface and subsurface soil samples will be collected using a statistically based triangular sampling grid The passive soil gas grid covers 250 000 square feet with nodes every 50 feet The soil sampling grid covers 150 000 square feet with nodes every 100 feet Based on the size of the Site and available information 20 collocated surface and subsurface soil samples are planned to provide adequate coverage within the main portion of the site Distributing these 20 sampling locations across the Site on the triangular sampling grid yields enough coverage to assess circular areas of contamination with a radius larger than approximately 53 feet (Gilbert 1987) Details of the sampling plan are presented in Section 4 2 7 below and in the SAP (Earth Tech 1998b) The two errors resulting from statistical approach are (1) False Positive Error which is assuming contamination does not exist when it actually does and (2) False Negative Error which is assuming contamination does exist when it actually does not These errors are discussed below

- **Decision Error "a "** Determining that contaminants in a 106 foot or greater diameter circle do not exist when they actually do The consequence of this error is contaminated soil will not be further investigated Decision Error a is the more severe decision error with regard to human and ecological exposure

  False Positive Error If there are circular areas of contaminated soil with a radius of 53 feet or greater a triangular grid sampling plan will have at least a 95 percent probability of finding an area of contaminated soil (less than 5 percent of a false positive error) In addition passive soil gas samples will be collected to detect a circular area of contaminated soil gas with a radius 28 feet or greater prior to collecting the soil samples The soil gas data will be used as one of the decision factors for the soil sampling plan The false positive error and possibly the radius of the contaminated areas will be reduced as a result

  Decision Error "b " Determining the soil is contaminated when in reality it is not The consequence of this error is that additional time and money will be spent on further response action A positive consequence is that it shows that the overriding concern is for protecting human health The consequences therefore are far less severe than the consequences of decision error a

  False Negative Error If no circular areas of contaminated soil with a radius of 53 feet or greater exist a triangular grid sampling plan will have at most a 5 percent probability of detecting the area of contaminated soil

The true state of nature for decision error a is that a circular area of contaminated soil with a radius of 53 feet or greater exists The true state of nature for decision error b is that there are no circular areas of contaminated soil with a radius 53 feet or greater

4 2 7 Optimize the Design

The RI involves collecting passive soil gas and surface and subsurface soil samples

Soil gas and soil sampling locations will be based on a triangular shaped grid pattern The justification for the triangular grid is provided below The distance between soil gas samples will be 50 feet (G_1) and the distance between the soil samples will be 100 feet (G_2) Passive soil gas sampling results will be used as a screening tool for the placement of the soil samples to optimize the systematic triangular grid

Surface and subsurface samples will be taken at the grid nodes and analyzed at a fixed based chemical laboratory Sampling locations and techniques are discussed in the SAP (Earth Tech 1998b) Sampling will be conducted on a triangular grid that achieves a pre specified confidence limit of greater than 95 percent Values used to calculate the radius of contamination (L) along with calculated values for each sampling method are provided in Table 4 1

For a radius of 53 feet or greater there is a probability of 5 percent that the circle of contamination will not be detected using a triangular grid system By applying the values of the probability of non detection (β) and the assigned value of the shape of the circle (S) to Figure 4 1 a value for L/G can be found and the radius of the circle of contamination (L) can be calculated

A comparison between the conventional square sampling pattern shows that if the distance between samples is 100 feet, then 24 samples must be collected to get a $\beta = 0\ 1$ This corresponds to a 90 percent confidence level that an area of contaminated soil with a radius of 53 feet will be detected A triangular sampling pattern shows that if the distance between samples is 100 feet then only 20 samples must be collected to get $\beta < 0\ 05$ This corresponds to a 95 percent confidence level that an area of contaminated soil with a radius of 53 feet will be detected (Gilbert 1987)

Table 4-1 Sample Area Size Determination

Variables	Symbol	Passive Soil Gas Samples	Soil Samples (Surface and Subsurface)
Number of samples in grid	n	118	20
Grid spacing	G (feet)	50	100
Shape of the circle of contamination (assigned value of 1)	S	1	1
Probability of not detecting circle of contamination	β	05	05
Ratio of circle radius to grid spacing used to calculate L	L/G	53	53
Value is acquired from nomogram—see Figure 4-1			
Radius of circle of contamination	L (feet)	28	53
L = (G)(L/G)			